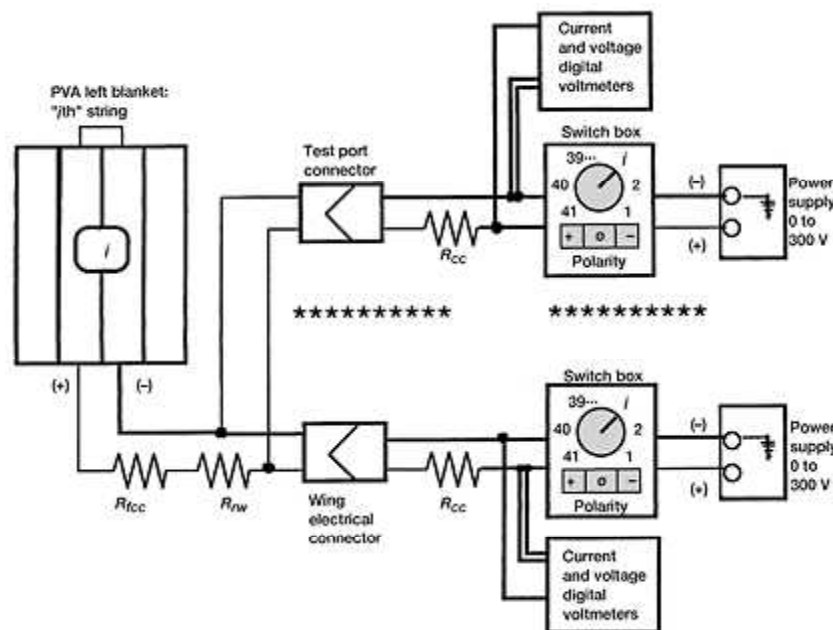


# Dark Forward Electrical Test Techniques Developed for Large-Area Photovoltaic Arrays

Spacecraft photovoltaic arrays (PVA's) must be carefully handled during ground integration processing and transportation to the launch site. Care is exercised to avoid damage that could degrade on-orbit electrical performance. Because of this damage risk, however, PVA's are typically deployed and illuminated with a light source so performance characteristics can be measured prior to launch. For large-area arrays, such as the Mir Cooperative Solar Array (2.7- by 18-m) and the International Space Station PVA blankets (4.6- by 31.7-m), this integrity check becomes resource intensive. Large test support structures are needed to offload the array during deployment in 1g, and large-aperture illumination equipment is required to uniformly illuminate array panels. Significant program time, funds, and manpower must be allocated for this kind of test program. Alternatively, launch site electrical performance tests can be bypassed with an attendant increase in risk.

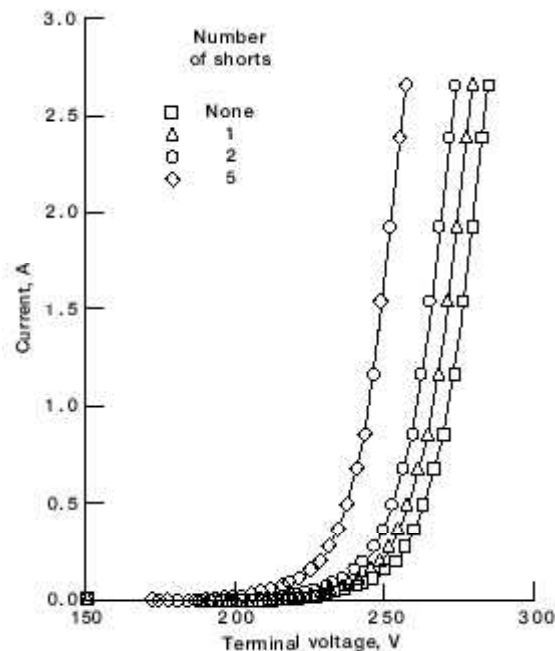


*Dark forward electrical testing.*

Another alternative is dark forward electrical testing. This testing is performed while the array stowed, obviating the need for deployment and illumination test support equipment. Dark test support equipment is inexpensive, it is easily portable to launch site facilities, and testing can be accomplished with only one or two test engineers. The dark test equipment consists of a direct-current power supply, a switching unit, a personal computer (PC), and instrumentation (several digital voltmeters) as shown in the schematic diagram. During dark testing, individual array strings are forward-biased to a preset voltage level

through the use of the power supply. With forward biasing, the polarity of the array during normal illuminated operation is matched. The resulting direct current is then measured. Several different current-voltage (IV) data points are obtained to generate the array's characteristic diode IV curve. The PC controls the power supply and collects and stores the data.

After testing, the data can be manipulated to obtain the illuminated electrical performance for the array. In addition, the diode IV data can be compared with computational predictions to determine PVA electrical performance degradation due to damage. Predictions are made for an undamaged array string and for strings with a variety of damage modes, such as bypass diode short-circuits, as shown in the following graph for an International Space Station PVA string. Using this information, program managers can make a firm decision to either proceed with spacecraft integration or send the PVA back to the supplier for the necessary repairs.



*Dark forward current-voltage response with bypass diode shorts,*

Dark forward electrical testing was successfully utilized in July 1995 to verify the performance of the Mir Cooperative Solar Array following its shipment to the United States from Russia. This testing helped to assure program managers that the Mir Cooperative Solar Array was ready for integration with the space shuttle as part of the payload for mission STS-74 to the Russian Mir space station. A feasibility study was also performed to assess dark test capabilities in verifying International Space Station PVA performance prior to launch. Since the trend in geosynchronous communication satellites is toward larger, higher power PVA's, dark forward electrical testing may become a key part of commercial spacecraft integration and checkout processing. Dark testing offers high-power, commercial satellite manufacturers an innovative tool to help contain costs and maintain tight launch schedules. These are among the key elements for maintaining marketplace competitive advantage.

## **Bibliography**

Kerslake, T.W.; Scheiman, D.A.; and Hoffman, D.J.: Pre-Flight Dark Forward Electrical Testing of the Mir Cooperative Solar Array. NASA TM-107496, 1997.

Kerslake, T.W.; Scheiman, D.A.; and Hoffman, D.J.: Dark Forward Electrical Testing of the Mir Cooperative Solar Array. Research & Technology 1996, NASA TM-107350, 1997, pp. 157-158.

**Lewis contacts:** Thomas W. Kerslake, (216) 433-5373, Thomas.W.Kerslake@grc.nasa.gov; David A. Scheiman, (216) 433-6756, David.A.Scheiman@grc.nasa.gov; and David J. Hoffman (216) 433-2445, David.J.Hoffman@grc.nasa.gov

**Authors:** Thomas W. Kerslake, David A. Scheiman, and David J. Hoffman

**Headquarters program office:** OSF

**Programs/Projects:** STS-74, ISS, Mir, MCSA